

Application Guideline

Optimising The L80-5000 Operation

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1. Introduction

The L80-5000 Water Vapour Permeability Tester is a relatively simple instrument to use on a basic level. Following just a few hours of training, the user can already perform sample testing. However, a full mastery of the use of the L80-5000 tester requires a period of repeated operation, during which the user acquires a deeper understanding of the behaviour of the instrument, how to interpret individual test results, and which settings provide the most effective testing cycles for that user's test samples.

The purpose of this manual is to provide some tips, recommendations and guidelines for the both the new and experienced L80-5000 user, based on our long accumulated experience in using this instrument. The manual begins with a brief review of permeability measurement and the basics of the L80-5000 operation, and then covers a number of practical topics related to the use of L80-5000 tester, including choosing an appropriate calibration film, optimisation of the calibration step, choice of testing parameters (settings), adjustment of air flow, and more.

We hope that this manual will help both present and future L80-5000 users to more quickly gain a deeper understanding of the instrument and to obtain the best results from their sample testing. The manual is also suitable for distributors and salespeople who wish to acquire a better understanding of the tester's principles and use for their discussions with potential customers.

2. A Brief Review of Permeability and its Measurement.

One of the most important properties of polymer films used in packaging and other applications is the ability to protect the product against contamination, spoilage or degradation, which is often caused by exposure to gases such as oxygen or water vapour. The permeability of a polymer material to gases and vapours is therefore a key indicator of its barrier properties. As a result, the measurement of permeability is essential to the development and production of high-barrier materials required in many modern packaging applications.

Please keep in mind that the mechanism of gas and vapour permeation through a polymer film and the measurement of this property can be quite complex. There are many factors that should be taken into consideration when evaluating permeability testers. What follows is a summary of some of the most important points to remember when dealing with permeability and the measurement thereof.

- Permeability is the migration of a gas or vapour through a “solid” film. It should not be confused with the travel of gas (normally air) through a porous material, such as a filter or a textile. The latter is sometimes referred to as permeability, but is actually **porosity**. The test methods for this property are different than for permeability testing and are not interchangeable.
- PERMEABILITY MEASUREMENT TAKES TIME. It is necessary ensure that the permeation has achieved steady state before the final measurements are reported. In many cases, it is necessary to condition (stabilise) the sample for many hours before even beginning measurement, and the measurement itself is normally repeated a number of times to compare the trend in results. **No matter what type of tester is used, the measurements take time, particularly in the case of high barrier (low permeability) materials.** It is vital to keep this point in mind.
- The rate of permeability is very temperature-dependent. On average, increasing the temperature just 10°C will double the permeation rate. Precise control of testing temperature is therefore critical to obtaining good results.
- Permeability rates can be expressed in different ways and using different units. When discussing numerical values for permeability, be sure to verify the units. Typical units for water (moisture) vapour transmission rate (WVTR or MVTR) are grams per square meter per day ($\text{g/m}^2/24 \text{ hr}$), but in the USA, WVTR/MVTR is often expressed as $\text{g}/100 \text{ in}^2/24 \text{ hr}$. **Conversion: $1 \text{ g/m}^2/24 \text{ hr} = 0,0645 \text{ g}/100 \text{ in}^2/24 \text{ hr}$**
- The water vapour transmission rate of a film is strongly dependent on the **driving force** across the film, which is also an expression of the measuring conditions used during the test. This driving force is expressed as **the difference in relative humidity between the wet side and the dry side of the film at a given measuring temperature**. For example, one of the most frequently used measuring standards is **38°C, 90% RH difference**. This specification means that the difference between the relative humidity on the wet side and the dry side of the film is 90% RH. On the L80-5000 tester, the conditions in the tester that give this difference are 100%RH on the wet side (lower chamber) and 10% RH on the dry side (upper chamber) at a temperature of 38°C. Some people refer to this testing condition as

38°C, 10% RH (relative humidity in the upper chamber, or dry side of the film). It is important not to confuse these different ways of specifying the measuring conditions.

For a more detailed examination of the mechanism of permeation and the factors influencing its measurement, please refer to the paper “Automatic Permeability Measurement – The Challenges and Solutions”, which is available from PBI-Dansensor A/S.

3. An Overview of L80-5000 Operation

Figure 1 illustrates the principle of the L80-5000 testing method. A film sample is inserted into the test chamber, where a system of O-rings seals the film at the perimeter and prevents leakage around the sample. The lower test chamber has a saturated atmosphere maintained by a small water reservoir, while the upper chamber contains a sensitive, fast-responding relative humidity sensor.

The upper chamber is first dried to a defined humidity level using dry air. When the drying is complete, the airflow stops and the valves close. From that point, the chamber is a closed system, in which transmission of water vapour through the sample causes an increase in relative humidity in the upper chamber, which is recorded by the humidity sensor in the chamber.

The instrument measures the time required for the upper chamber humidity to increase from a pre-defined lower limit to a pre-defined upper limit. The measured time interval is compared to the time obtained during calibration with a standard film of known permeability, and the result is expressed as the water vapour transmission rate in $\text{g/m}^2/24 \text{ hr}$.

The test cycle is repeated until the variation in the results reaches a defined level of repeatability, indicating that the sample has reached equilibrium.

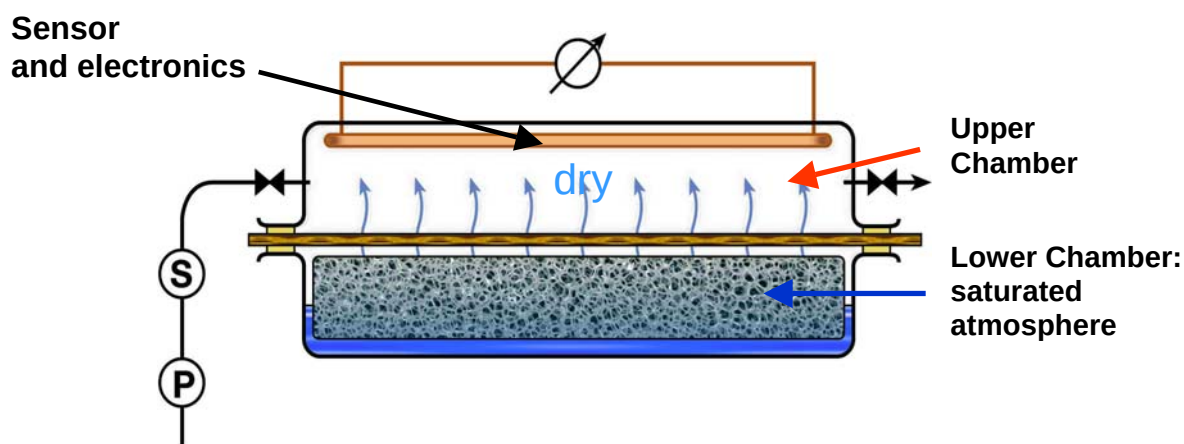


Figure 1 - Measuring Principle of the L80-5000 tester.
Compares time required for incremental RH increase in Upper Chamber (i.e. 9.5 → 10.5 % RH)

4. Calibration Film Standards for L80-5000

The L80-5000 tester is a relative instrument, meaning that the instrument must be calibrated with a known sample prior to measurement. As stated above, the L80-5000 determines the permeability of the measured sample by comparing the time required for the incremental change in relative humidity in the upper chamber to that required for a **standard calibration film of known permeability**. As a result, the attainment of meaningful measurement results from the L80-5000 is fully dependent on the use of accurately measured calibration standard films.

We have recently revised our selection of calibration films for the L80-5000 and have purchased all new film materials. Representative samples of each of these new L80-5000 calibration films have been measured using the Gravimetric (Cup) method at Packaging Systems and Enterprises Inc., an external laboratory in the USA. These measurements will be repeated every two (2) years in order to verify the permeability values of these films.

Table 1 below summarises the calibration films now available for the L80-5000 tester, along with the measured WVTR values for each film.

Table 1
WVTR Calibration Values for Normal Testing Conditions (g/m²/24 hr)

Film Type	38°C/90% RH diff. ¹	23°C/85% RH diff.	40°C/90% RH diff. ²
19 my PET	25,0	10,5	---
36 my PET	14,0	5,8	---
20 my PCTFE ("Aclar")	0,26	0,12	---
250 my PET	2,0	---	2,3
Goretex® ³	5000	2200	---

Notes for Table 1:

1. Conversion of RH designation: 100 – RH diff. = RH in upper chamber (Example: 38°C/90% RH diff. = 38°C/10% RH in L80-5000 upper chamber)
2. 40°C/90% RH diff are testing conditions used primarily in Japan
3. The calibration values for the Goretex membrane were determined by the direct testing of the membrane on L80-4000/5000 using 19 my PET standard as the calibration standard. These calibration values have since been accepted by consensus within the EDANA group (European Nonwovens organisation).

With each calibration film, a test certificate showing the measured calibration values for each set of testing conditions is provided.

The 19 my PET, 36 my PET, 20 my "Aclar" and Goretex calibration films are now included with the standard scope of supply of a new L80-5000 tester. The 250 my PET film is not considered a standard calibration film, but is available for sale separately for those who wish to use this material.

5. Choosing an Appropriate Calibration Film for Your Testing

The choice of appropriate calibration film is dependent on the expected permeability range of the sample(s) to be measured. It is normally recommended to use the calibration film having the value that is closest to the expected permeability range of the films to be measured.

That being said, it is not always possible to know in advance the permeability range of the materials to be tested. In such a case, the user must use his/her judgement to select an appropriate calibration film. In the worst case, if the test film is found to be in a significantly different range than the calibration film, a new calibration can be made using a different standard film.

Table 2 provides a rough guideline for the selection of calibration standard films based on the range of permeability values to be measured, given for the two most commonly used testing conditions.

Table 2
Rough Guidelines for Choice of Calibration Film

Cal. Film Type Test Conditions→	Range of WVTR values for sample films, g/m ² /24 hr	
	38°C/90% RH diff.	23°C/85% RH diff.
19 my PET	10-200	5-100
36 my PET	1- 10	1- 5
20 my PCTFE ("Aclar")	< 1	< 1
Goretex®	>200	>100

Once again, we wish to stress that the above table is intended as a general guideline only, and individual users may adapt their choice of calibration films to best suit their specific needs.

In conjunction with the choice of calibration film, the user must also choose the appropriate settings (operating parameters) for the L80-5000 tester. We provide our suggestions and recommendations for the choice of instrument operating parameters in the next section of this manual.

6. Choosing Appropriate Operating Parameters for Your Testing

The set-up of the L80-5000 for operation includes the specification of a number of instrument settings, known as operating parameters. A complete list and explanations of all the operating parameters of the L80-5000 is available in the User Manual for the L80-5000. This guide will not provide exhaustive coverage of all of these parameters. Instead, we will review several of the key parameters that are chosen as a function of the samples to be tested, by the best judgment of the user. For these vital parameters, we provide some tips and suggestions for choosing appropriate values for your testing. **Please note that all of the following operating parameter recommendations apply to the L80-5000 tester with the L type humidity sensor, or any older tester that has been upgraded to the L sensor type. For older instruments (L80-4000 K or earlier or L80-5000 K), different settings will apply. All users of older instrument types should contact PBI-Dansensor A/S for recommended settings for their unit type.**

A. Measuring interval parameters: Upper Limit (UL), Lower Limit (LL) and Underdry (UD): These parameters are vital to the L80-5000 performance, since they determine the precise interval of relative humidity increase which is measured during a testing cycle. The choice of upper limit (MEMO 05) and lower limit (MEMO 06) will determine both the length of the measuring cycle, and the average humidity level at which the measurement will take place.

The following guidelines apply to choosing the measurement interval parameters:

1. **Centering the measurement interval:** In the most commonly used relative humidity range (MEMO 07) of 10/15%, a value of 500 scale divisions is normally equivalent to 10% RH in the upper chamber, and a value of 750 scale divisions is normally equivalent to 15% RH. When performing a test at the standard conditions of 38°C/90% RH diff., the measuring interval should be approximately centered at a value of 500 scale divisions, so that the overall average RH in the upper chamber during the measuring cycle is 10% RH. Similarly, for a measurement at 23°C/85% RH diff., the measuring interval should approximately center around 750 scale divisions. In many cases, the centering also factors in the Underdry interval (see Point 2)
2. **Underdry interval (MEMO 03):** The Underdry value represents the number of scale divisions BELOW THE LOWER LIMIT that the upper chamber is dried to before the air pump shuts off. The purpose of the Underdry interval is to allow the humidity increase in the upper chamber due to permeation through the film to become linear prior to the beginning of the measurement, leading to a more stable, consistent measuring result. As a general rule, the underdry value should be at least one third of the size of the measurement interval itself (upper limit – lower limit). For example, for a measurement interval of 490 to 520 (30 scale divisions), the Underdry value should be at least 10 scale divisions.
3. **Size of measurement interval:** Choosing the size of the measurement interval (upper limit – lower limit) involves finding a compromise between the length of time required for each measurement and the degree of accuracy desired for the individual measurements. Since the precision of the L80-5000 tester is +/- 1 scale division on each end of the measurement interval, the smaller the overall interval size, the larger the potential deviation caused by this precision limit. For example, a measurement made over an interval of 20 scale divisions would be twice as fast as one made over 40 scale divisions. However, with a measurement interval of 20 scale divisions, the potential error is +/-10% of the overall value (1 scale division on each end = $2/20 = 10\%$). For a measurement interval of 40 scale divisions, this error decreases to +/-5%. For this reason, we rarely recommend using a measurement interval smaller than 10-15 scale divisions. In most cases, the user should try to optimize the measurement interval to give the fastest possible testing times, while maintaining an acceptable degree of accuracy. **To ensure sufficient accuracy of the overall measurements, the measurement interval should be large enough to ensure that each individual measurement cycle is at least 100 counts in length.**

B. Other Relevant Operating Parameters: in addition to the measurement interval parameters, there are several other parameters to be considered.

1. **Number of Underdry Cycles (MEMO 11):** Underdry cycles are used during the measurement of high permeability samples only ($>500 \text{ g/m}^2/24 \text{ hr}$) to achieve faster measurement stability. We generally recommend 2 or 3 Underdry cycles for high permeability sample measurements only.
2. **Number of Humidity Compensation Cycles (MEMO 14):** For the L80-5000 testers containing the L sensor type, this parameter is not normally used, and is most often set to 0.
3. **Time Base (MEMO 16):** This parameter determines whether each count is equivalent to 1/10 of a second or 1 second. For samples of low permeability ($<1 \text{ g/m}^2/24 \text{ hr}$), a setting of 1 second should be used. Otherwise, 1/10 second is used.
4. **Tolerance of measurements in % (MEMO 19) and Number of Measurements within Tolerance (MEMO 20):** These parameters are used to determine the stability criteria for which the L80-5000 will report a result in equilibrium. Normally, we use values of 1,5% for MEMO 19 and 5 measurements for MEMO 20, but it is up to the individual user to determine the degree of precision of the measurement that is desired, and the level of stability that constitutes a completed measurement.

With these guidelines in mind, we present some suggestions for measurement interval parameters for various permeability ranges. Table 3 contains suggestions for the standard conditions of $38^\circ\text{C}/90\% \text{ RH diff.}$, while Table 4 contains suggestions for testing conditions of $23^\circ\text{C}/85\% \text{ RH diff.}$. Please keep in mind that these are general recommendations only, and may be adapted to the needs of the individual user.

Table 3
Recommendations for Measurement Interval Parameters: $38^\circ\text{C}/90\% \text{ RH diff.}$

Perm range $\text{g/m}^2/24 \text{ hr}$	<1	1-10	10-200	>200
Calibration Film	20 my Aclar	36 my PET	19 my PET	Goretex
Calibration Value $\text{g/m}^2/24 \text{ hr}$	0,26	14,0	25,0	5000
Upper Limit, scale divisions	510	510	520	600
Lower Limit, scale divisions	495	495	490	450
Underdry, scale divisions	15	10-15	10-20	50
Number of Underdry cycles	0	0	0	2-3
Number of Humidity Comp.	0	0	0	0
Time Base	1 sec	1/10sec	1/10 sec	1/10 sec
Tolerance % for equil.	1,5%	1,5%	1,5%	1,5%
Number of meas. in tolerance	3-5	3-5	3-5	3-5

Table 4
Recommendations for Measurement Interval Parameters: 23°C/85% RH diff.

Perm range g/m2/24 hr	<1	1-5	5-100	>100
Calibration Film	20 my Aclar	36 my PET	19 my PET	Goretex
Calibration Value g/m2/24 hr	0,12	5,8	10,5	2200
Upper Limit, scale divisions	760	760	770	850
Lower Limit, scale divisions	745	745	740	700
Underdry, scale divisions	15	10-15	10-20	50
Number of Underdry cycles	0	0	0	2-3
Number of Humidity Comp.	0	0	0	0
Time Base	1 sec	1/10 sec	1/10 sec	1/10 sec
Tolerance % for equil.	1,5%	1,5%	1,5%	1,5%
Number of meas. in tolerance	3-5	3-5	3-5	3-5

7. Verifying Suitability of the Measurement Interval

Once a measurement interval has been set, it is a good idea to verify that this interval is suitable for the film(s) to be tested. To verify the interval, insert the desired test film(s) or calibration film into the chamber, and start a measurement by pressing SAMPLE. Allow the tester to perform several measurement cycles. At this point, the tester has not been calibrated, and the permeability value shown on the printout will likely be incorrect. That does not matter at this point, because the purpose of this step is to determine the number of counts required for each measurement cycle.

As mentioned earlier, the measurement interval is chosen to optimise the length of the measurement cycle, while maintaining the best possible repeatability and lowest percentage of error. For satisfactory repeatability and minimum error, each sample to be tested should have a measurement cycle of no less than 100 counts. If any of the samples to be tested finish the cycle in less than 100 counts, the measurement interval should be widened. In the case of extremely fast measurements, the sample in question may be of such high permeability as to require a sample reduction card. In such a case, the calibration film to be used will normally be Goretex.

Conversely, if a larger measurement interval has been chosen, but the samples in question display a very long measurement time (>4000 counts), it may be advisable to narrow the measurement interval to obtain faster measurements.

Once the verification process has been performed for all of the sample types to be measured, the measurement interval is accepted and the user can proceed to the calibration step. Prior to beginning the calibration (TEST STD), we recommend to pre-condition the calibration film. A description of this procedure is given in the next section.

8. Pre-conditioning of the Calibration Standard Film

During the calibration (TEST STD) procedure, the time required for the incremental increase in relative humidity is measured for the calibration (Test Standard) film of

known permeability. This measured time interval is then multiplied by the known permeability of this test standard film in order to determine the Calibration Factor for the run. This calculated factor is shown progressively for each measurement cycle of the calibration film. Once the tester reaches the First Result in Equilibrium, as determined by the tolerance criteria described above, the calibration factor is then stored in the tester memory, and becomes the basis for all subsequent sample measurements made for those testing conditions thereafter.

Since the factor is the basis for calculation of the permeability of all samples measured following the calibration, it is important to ensure that the saved factor is an accurate measurement of that calibration film. One part of this control is to ensure that the water vapour permeation through calibration standard film is in equilibrium (steady state) when the factor is determined and stored.

In our experience, the permeability of a film can continue to change even after the L80-5000 tester finds a "first result in equilibrium". If the rate of change is very slow, the tester can release a result as being in equilibrium even while the result continues to drift. Normally, this further drift results in a relatively small change to the final measured value (<10% variation), but in some cases, particularly for thick and/or high barrier materials, the drift can be so slow and gradual that the measured value can change significantly over time from the result recorded at first result in equilibrium.

In order to prevent the premature storage of a calibration factor before the film is finished stabilizing, we therefore recommend the pre-conditioning of the calibration film before running the calibration (TEST STD).

This pre-conditioning is accomplished by inserting the calibration standard film into the tester, selecting the parameters to be used for the calibration, and pressing the SAMPLE key. The tester will now begin to measure the calibration standard film as if it were a normal sample. Since the operating parameters have presumably just been changed in preparation for a new calibration, the reported WVTR during this pre-conditioning step will most likely not be correct. **Please note that during this pre-conditioning step, the reported WVTR value of the calibration film is NOT relevant, and should be ignored.**

Once the test is started, the user adjusts the airflow to achieve the optimal drying level, and then monitors the number of counts required per measuring cycle. The pre-conditioning test is allowed to run until the number of counts per measurement cycle has stabilized. Stability is determined by examining the trend in counts over at least 10 measurement cycles. A stable sample will display a constant or gently oscillating count number with no continuous drift in one direction.

Once the user determines that the count number is sufficiently stable, and no further drift is occurring, the pre-conditioning test is stopped. Immediately after, the TEST STD (calibration) run is immediately started with the same operating parameters. Since the calibration film is now in steady state, the calibration run should then finish within relatively few measurement cycles, giving a factor that accurately reflects the steady state permeability of that film.

This pre-conditioning step is particularly important for the lower permeability and thicker calibration standard films, such as the 20 my Aclar film and the 250 my PET film. It is also recommended for use with the 36 my PET film.

9. Adjustment of Airflow During Testing

During the drying step of the testing cycle, air from the surroundings is pumped through the silica gel cartridge and into the upper chamber. This airflow dries out the upper chamber in preparation for the measurement of the humidity increase in the chamber during the testing phase. Since water vapour continues to permeate from the lower chamber through the sample during the drying phase, the airflow must be high enough to carry away this influx of water vapour as it enters the upper chamber. Depending on the permeability of the sample itself, higher or lower flows of air will be required to accomplish the drying.

On the front of the L80-5000, there is a small valve for adjustment of the airflow to the upper chamber during the drying phase. This valve controls a slipstream (bypass) of air from the air pump to the silica gel drying material. When the valve is fully closed, all of the drying air is routed through the silica gel filter to the upper chamber, and the dry airflow to the chamber is maximized. This high airflow is used in the case of high permeability (breathable) materials, where significant airflow is needed to counteract the high water vapour permeation from the lower chamber.

On the other hand, when the valve is fully open, a significant portion of the drying air escapes to the atmosphere through the bypass, and the flow of dry air from the silica gel filter to the chamber is lower. This valve position is used for low permeability (barrier) samples, where little air is needed to counteract the water vapour permeation from the lower chamber.

The airflow is adjusted by turning the valve. Turning in a clockwise direction increases the airflow to the chamber, while turning in an anticlockwise direction decreases the flow to the chamber. The valve is a precision valve, and there are perhaps 20 full rotations of the valve from fully open to fully closed. Therefore, it is normally necessary to turn the valve at least one full turn to make an adjustment to the flow.

During the beginning of a measurement, the airflow is adjusted by watching the drying speed during the dry-down. An ideal drying speed is about 1-2 counts per second. The best indication of the airflow level is the degree of "undershoot" of the upper chamber humidity once the drying air valve is closed. The drying valves close once the humidity of the upper chamber (scale divisions) fall below the lower limit minus the underdry valve. For example, for a lower limit of 490 and an underdry of 10, the drying valves will close once the scale divisions fall below 480.

Ideally, the "undershoot" should be less than 20 scale divisions. For the example given above, the scale divisions should not drop below 460 following the closing of the drying valves. Excess undershoot indicates that the drying airflow is too high,

and the excess air is causing a larger drop in upper chamber RH following the drying step. While this excess drying is not a serious problem, it does extend the length of the run, since the tester must wait until the RH in the upper chamber increases back to the lower limit before the start of the next step. Therefore, it is desirable to adjust the airflow to maintain the “undershoot” below 20 scale divisions.

In the case of excess airflow, the tester will indicate an alarm after each measuring step which reads “UNDERDRY DOWN TO XXX, REDUCE AIR FLOW”, where XXX is the lowest value recorded in the upper chamber during that particular drying step. This indication alerts the user to the excess airflow, which then can be reduced by rotating the front air valve.

10. Interpretation of Testing Results and Verification of Equilibrium

Once the tester is calibrated, the sample film inserted and the airflow adjusted to a suitable range, the testing of the sample is in progress. The last major step that remains is the interpretation of the testing results.

In the measurement of permeability, it is important to determine whether the test sample has reached equilibrium, or steady state. At this point, the permeant flow through the material has become stable over time, and the measured transmission rate at this time will be the “correct” permeability for the material. If the permeability of a material is measured before it has reached steady state, the result obtained will not be the “final” result and will therefore be inaccurate.

The L80-5000 has a built-in algorithm (“Trend Monitor”) to monitor the change in water vapour transmission rate from one test cycle to the next, in order to determine when the reaction is stabilising and reaching equilibrium. When the tester is operated with “TREND MONITOR ON”, the tester keeps a rolling average of measurement cycles and examines the change over time. The criteria for reaching equilibrium are chosen by the user, and are expressed as a maximum tolerance level (in %) measured over a certain number of cycles. For example, a commonly used set of criteria are a tolerance of 1,5% over 5 measurement cycles. Once the change in permeability over 5 consecutive cycles falls within this tolerance, the tester will issue the message, “FIRST RESULT IN EQUILIBRIUM”.

It is important to note that the water vapour transmission rate results that are printed at the end of each measurement cycle are the rolling averaged results from the Trend Monitor. In order to best monitor the change in results from one cycle to the next, it is best to observe the NUMBER OF COUNTS required for each measurement cycle. The count number of each cycle reflects the behaviour of the film in that cycle only, and does not reflect a rolling average.

Under normal operating parameters, the L80-5000 tester does not stop testing once this equilibrium message is printed. Rather, it continues to test until the user stops the tester.

A frequently asked question is, “when is the correct time to stop the L80-5000?” The answer to this question depends most on the individual user and what he/she

wishes to accomplish with the L80-5000. Some users wish to determine a rough, "order-of-magnitude" water vapour transmission rate for a given material. For such a user, it is not important that the final result is precise to within a few percent. Depending on the specific needs, this user may allow the tester to run just a few cycles, or may stop the tester just after the "FIRST RESULT IN EQUILIBRIUM" message is printed. Other users may wish to determine the precise water vapour transmission rate of a material, and such users will allow the test to run long after the equilibrium message appears, to determine whether the result changes further.

As a result, it is not possible to provide general guidelines for all users in regard to the appropriate time to stop the tester. However, we can provide our recommendations for best results for the majority of users testing unknown samples. We normally recommend allowing the tester to continue to test for at least 5-10 cycles after the "FIRST RESULT IN EQUILIBRIUM", to determine whether the test result continues to drift in one direction. If a continuous drift is observed, allow the tester to continue measuring until the drift ceases, and the results stabilise and/or oscillate around a central value. Once again, it is important to monitor the number of counts per cycle instead of just the printed water vapour transmission rate, since the latter is a rolling average and can lag behind the change in counts from cycle to cycle.

The number of measurements required to achieve steady state depends on a number of factors, such as the permeability of the material (the lower the permeability, the longer the reaction needs to reach equilibrium), the thickness of the material (the thicker the film, the longer it needs), and the temperature of measurement (the lower the temperature, the longer it needs). It is not possible to provide a rule that covers all film types. In general, it is always better to be on the conservative side, and allow the tester to run extra cycles instead of stopping it prematurely.

11. Conclusion

The guidelines presented in the above 10 sections are a collection of our experiences testing with the L80-5000 Water Vapour Permeability Tester and answers to some of the most frequently asked questions about the operation of this instrument. We hope that they will be helpful for your use of the L80-5000. If at any time you have questions about the use of your tester or testing results obtained from the L80-5000, you are welcome to contact your local distributor or PBI-Dansensor A/S directly.